DEVELOPMENT OF AN INCHWORM DEEP SUBSURFACE PLATFORM FOR IN SITU INVESTIGATION OF EUROPA'S ICY SHELL. T. Myrick[1], S. Frader-Thompson[2], J. Wilson[3], S. Gorevan[4], [1]Honeybee Robotics, 204 Elizabeth Street, New York, NY, 10012, Myrick@HoneybeeRobotics.com, [2]Honeybee Robotics, 204 Elizabeth Street, New York, NY, 10012, Frader@HoneybeeRobotics.com, [3]Honeybee Robotics, 204 Elizabeth Street, New York, NY, 10012, Wilson@HoneybeeRobotics.com, [4]Honeybee Robotics, 204 Elizabeth Street, New York, NY, 10012, Gorevan@HoneybeeRobotics.com.

Introduction: Honeybee Robotics is presently developing a drill system that may be well suited for a landed Europa exploration mission due to its currently estimated penetration depth, size, power requirements, and payload capabilities. The Inchworm Deep Subsurface Platform moves in a locomotive fashion, advancing one section of the drill while the other is anchored to the borehole wall. This system has the potential to drill hundreds of meters to several kilometers below the surface of Europa, depending on whether the system is tethered or untethered. Interesting subsurface targets on Europa such as the liquid ocean below the icy shell and bacteria potentially imbedded within the shell can be studied in situ using an Inchworm Platform. Ice shell thickness estimates range from a few kilometers [1] to tens of kilometers thick [2] and bacteria location estimates range from the bottom of the Europan ocean floor [3] to the near surface. The Inchworm Platform is an ideal candidate for accessing these sites for in situ investigations.

Drill Technology and Development: Maturation of the Inchworm technology is currently funded under NASA's Planetary Instrument Definition and Development (PIDD) and Astrobiology Science and Technology for Exploring Planets (ASTEP) programs, managed by the Office of Space Science. The Inchworm concept is highly complex and innovative and currently much research and development (R&D) is required to address the development tall poles, including drill bit design, inchworm mobility method and drill cuttings removal, among others. However, the concept framework is already well supported by years of planetary exploration drilling R&D by Honeybee (under contract to NASA).

Volume and Power: The size of the device is constrained by limits on power, torque, and downforce available for drilling through hard rocks and ices on the upper end and by mechanism miniaturization limits and packaging constraints on the lower end. A current estimate of the Inchworm's dimensions is approximately 4 inches in diameter by 4 feet in length. Such a compact system minimizes force, torque and power requirements while still maintaining the ability to accommodate a science payload and an internal power supply. For a planetary body such as Europa, minimizing power and downforce requirements may improve the Inchworm's capability to maintain the pristine environment. Alteration and contamination of the environment may be minimized by controlling the Inchworm's thermal output (mainly attributed to internal power generation and drilling friction) so that phase change of the ice is avoided.

Mobility. While drilling, the Inchworm Platform reacts torque and thrust into the borehole wall. By keeping one set of borehole wall shoes (on either the forward or aft section) firmly secured to the borehole wall, the other section is able to expand or retract, allowing the drilling system to move up or down the borehole (Figure 1). This method of walking is independent of gravity and allows for the Inchworm to traverse the borehole back up to the surface for cuttings removal.

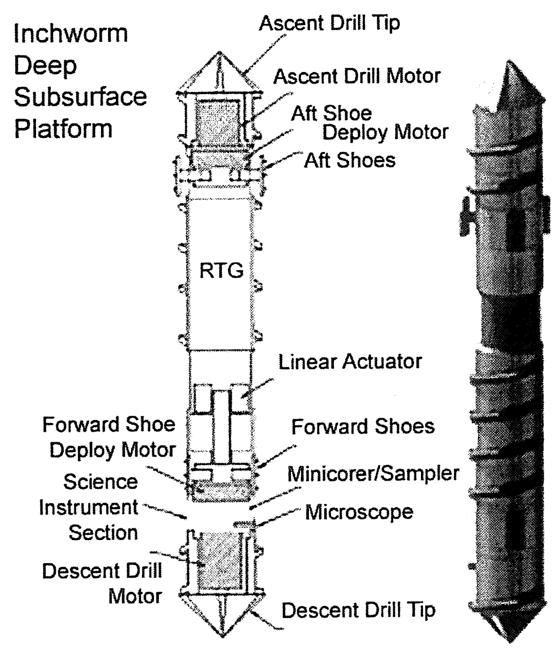

Figure 1: Inchworm Mobility System Schematic

Subsurface Access. Two mission architectures can be accommodated by the Inchworm design, a tethered drill platform capable of accessing a few hundred meters below the surface, or an untethered, fully-autonomous platform that can traverse kilometers in depth. Both configurations are challenging and offer various trades. A tethered system allows the power supply to remain at the surface, feeding power and data through the tether itself. The Inchworm could then accommodate a larger science payload and/or reduce the overall system volume, which would reduce requirements on force, torque and power. However, the drill's achievable depth would be limited by the length of the tether, which in turn would be limited by the tether management system's mass and volume constraints as well as mission complexity and risk issues. Tether management for a system that travels to depths below a few hundred meters may be an insurmountable engineering problem. Therefore, an Inchworm requiring no tether or umbilical of any kind is desirable since it removes the need for massive tether management systems. The achievable depth by such a system is mechanically unconstrained, although telecom and operation temperature requirements may be limiting factors.

Conclusion: The concept and design of the Inchworm drilling system is supported by years of extensive research, development and testing performed by Honeybee Robotics on related projects. However, the majority of the previous work has focused on drilling and sampling consolidated and unconsolidated rock. Development under the current funding vehicles will focus on deep drilling through rock, although similar Inchworm designs and drilling routines may be used for drilling ices at low temperatures, such as those found on Europa. The Inchworm Platform is an ideal mechanism for deep subsurface access on Europa, since it offers a robust method of drilling and mobility, can accommodate different mission architectures and various science payloads, and can potentially minimize alteration and contamination of the pristine Europan environment.

References: [1] Pappalardo R. T., Head J. W., Greeley R., Sullivan R. J., Pilcher C., Schubert G., Moore W. B., Carrk M. H., Moore J. M., Belton M. J. S., and Goldsby D. L., (1998), Nature, 391, 365-368. [2] Schenk, P. M., (2002), Nature, 417, 419 - 421. [3] Chapelle F. H., O'Neill K., Bradley P. M., Methe B.A., Ciufo S.A., LeRoy L. Knobel and Lovley L. R., (2002) Nature, 415, 312 - 315.